

CLAIMS

1. Device for the conversion of optical radiation, comprising:
at least one incident beam of input optical radiation;
a multilayer structure containing one or more layers with a negative dielectric constant and one or more other layers with a positive dielectric constant designed so that the said multilayer structure supports at least one surface plasmon-polariton mode, and designed so that at least one of said modes allows the optical parametric interaction of two surface plasmon-polaritons of angular frequencies ω_a and ω_b , resulting in the conversion to a frequency-upshifted surface plasmon-polariton with angular frequency $\omega_a + \delta$ and a surface plasmon-polariton, downshifted by an equal amount, with angular frequency $\omega_b - \delta$, where δ is a particular angular frequency shift or set of angular frequency shifts and one or both of said angular frequencies ω_a and ω_b is an angular frequency or set of angular frequencies present in at least one of the said incident beams of input optical radiation;

means for electrical coupling into a subset of said surface plasmon-polariton modes at said angular frequencies ω_a or ω_b or said angular frequencies $\omega_a + \delta$ or $\omega_b - \delta$ of the said multilayer structure;

means for coupling said input optical radiation into one or more of said surface plasmon-polariton modes at said angular frequencies ω_a or ω_b or said angular frequencies $\omega_a + \delta$ or $\omega_b - \delta$ of the

said multilayer structure;

means for coupling output optical radiation at angular frequencies $\omega_a + \delta$ or $\omega_b - \delta$ out of the said multilayer structure;

means for coupling output optical radiation at angular frequency ω_a and ω_b out of the said multilayer structure; and

means for coupling output optical radiation at angular frequencies other than ω_a , ω_b , $\omega_a + \delta$ or $\omega_b - \delta$ out of the said multilayer structure

2. Device for the conversion of optical radiation of claim 1, characterized by the said subset of said surface plasmon-polariton modes being null, so that said means for electrical coupling is absent.

3. Device for the conversion of optical radiation of claim 1, characterized by the said two surface plasmon-polaritons of angular frequencies ω_a and ω_b having equal angular frequencies $\omega_a = \omega_b$, which is referred to as $\omega_a = \omega_b = \omega_0$.

4. Device for the conversion of optical radiation of claim 1 and 3, characterized by point or points on the dispersion relation of the said surface plasmon-polariton mode or modes corresponding to the points of inflection on the said dispersion relation.

5. Device for the conversion of optical radiation of claim 1,

characterized by the said incident beam or beams of input optical radiation being composed of a pulse or pulses of coherent laser radiation with a well-defined central angular frequency.

6. Device for the conversion of optical radiation of claim 1, characterized by the said incident beam or beams of input optical radiation being composed of continuous wave laser radiation with a well-defined central angular frequency.

7. Device for the conversion of optical radiation of claim 1, characterized by the said incident beam or beams of input optical radiation being composed of a combination of a pulse or pulses of coherent laser radiation with well-defined central angular frequency or frequencies and continuous wave laser radiation with well-defined central angular frequency or frequencies.

8. Device for the conversion of optical radiation of claim 1, characterized by the said means for electrical coupling into a subset of said surface plasmon-polariton modes being an electric current passed through one or more of said layers with a negative dielectric constant or one or more of said other layers with a positive dielectric constant or combinations of these.

9. Device for the conversion of optical radiation of claim 1, wherein said device is used to produce frequency-converted output

optical radiation.

10. Device for the conversion of optical radiation of claim 1 and 9, characterized by the said incident beam or beams of input optical radiation being composed of a single said incident beam of input optical radiation.

11. Device for the conversion of optical radiation of claim 1 and 9, wherein the device is used to produce frequency-converted output optical radiation that is has a wider frequency spectrum than the said incident beam or beams of input optical radiation.

12. Device for the conversion of optical radiation of claim 1, 9 and 11, wherein the said output optical radiation has a component that consists of a supercontinuum.

13. Device for the conversion of optical radiation of claim 1, wherein said device is used to modulate the frequency, amplitude, optical phase or state of polarization of at least one frequency-component of the said output optical radiation.

14. Device for the conversion of optical radiation of claim 1, 3 and 13, characterized by the said incident beam or beams of input optical radiation being composed of two beams: an incident beam of input optical radiation with central angular

frequency ω_0 and an incident beam of input optical radiation with central angular frequency $\omega_0 + \delta$ or $\omega_0 - \delta$, where δ is a particular angular frequency shift or set of angular frequency shifts.

15. Device for the conversion of optical radiation of claims 1, 3 and 14, wherein the said device is used to produce a said output optical radiation at angular frequencies $\omega + \delta$ or $\omega - \delta$ that is modulated by the said device, where δ is a particular angular frequency shift or set of angular frequency shifts, and $\omega_a = \omega_b = \omega_0$.

16. Device for the conversion of optical radiation of claims 1, 3 and 14, wherein the said device is used to produce a said output optical radiation at angular frequency ω_0 that is modulated by the said device.

17. Device for the conversion of optical radiation of claim 1, 3 and 14, characterized by the said incident beam or beams of input optical radiation being composed of three beams, an incident beam of input optical radiation with central angular frequency ω_0 and two incident beams of input optical radiation with central angular frequencies $\omega_0 + \delta$ and $\omega_0 - \delta$, wherein the said device is used to produce said output optical radiation at angular frequency ω_0 , $\omega_0 + \delta$ or $\omega_0 - \delta$ or a combination of these angular frequencies that is modulated by the said device, where δ is a particular angular frequency shift or set of angular frequency

shifts, and $\omega_a = \omega_b = \omega_0$.

18. Device for the conversion of optical radiation of claim 1, wherein said device is used to amplify at least one frequency-component of the said input optical radiation.

19. Device for the conversion of optical radiation of claim 1, 3 and 18, characterized by the said incident beam or beams of input optical radiation being composed of two beams, an incident beam of input optical radiation with central angular frequency ω_0 and an incident beam of input optical radiation with central angular frequency $\omega_0 + \delta$ or $\omega_0 - \delta$, wherein the said device is used to produce amplified output optical radiation at angular frequencies $\omega_0 + \delta$ or $\omega_0 - \delta$, where δ is a particular angular frequency shift or set of angular frequency shifts, and $\omega_a = \omega_b = \omega_0$.

20. Device for the conversion of optical radiation of claim 1, characterized by the said multilayer structure being composed of planar layers with parallel interfaces.

21. Device for the conversion of optical radiation of claim 1, characterized by the said multilayer structure being composed of layers that possess a radius of curvature or radii of curvature.

22. Device for the conversion of optical radiation of claim

1, characterized by the said multilayer structure being composed of layers, at least one of which has a cross section in the form of a wedge.

23. Device for the conversion of optical radiation of claim 1, characterized by the said multilayer structure being composed of layers, at least one of which has the form of a waveguide with an axis oriented parallel to the layers of the said multilayer structure and bounded by two surfaces perpendicular to said layers of the said multilayer structure.

24. Device for the conversion of optical radiation of claim 1 and 23, characterized by the said axis of said waveguide being a straight line.

25. Device for the conversion of optical radiation of claim 1 and 23, characterized by the said axis of said waveguide being a curved line.

26. Device for the conversion of optical radiation of claim 1, characterized by the said layers with a negative dielectric constant of said multilayer structure being composed of metal.

27. Device for the conversion of optical radiation of claim 1, characterized by the said layers with a negative dielectric

constant of said multilayer structure being composed of semiconductor or doped semiconductor.

28. Device for the conversion of optical radiation of claim 1, characterized by the said layers with a negative dielectric constant of said multilayer structure being composed of a combination of metal, semiconductor or doped semiconductor layers.

29. Device for the conversion of optical radiation of claim 1, characterized by part of said multilayer structure being composed of a sandwich made up of a odd number of materials with one said layer with a negative dielectric constant at the centre, and with said other layers with a positive dielectric constant disposed symmetrically either side.

30. Device for the conversion of optical radiation of claim 1 and 29, characterized by part of said multilayer structure being composed of a sandwich made up of five materials in the order dielectric layer 1, dielectric layer 2, layer with a negative dielectric constant, dielectric layer 2, dielectric layer 1, where the terms dielectric layer 1 and dielectric layer 2 refer to said dielectric layers with different dielectric constants.

31. Device for the conversion of optical radiation of claim

1, characterized by the said multilayer structure being composed of layers that are thin enough for the said multilayer structure to be considered as a graded distribution of dielectric constant in the direction perpendicular to the said layers.

32. Device for the conversion of optical radiation of claim 1, characterized by the said multilayer structure being equipped with reflectors oriented perpendicular to the layers to allow the multiple reflection of said surface plasmon-polaritons inside the said multilayer structure and thus enhance the efficiency of the said device.

33. Device for the conversion of optical radiation of claim 1, characterized by the said multilayer structure being equipped with reflectors oriented perpendicular to the layers to allow the multiple reflection of said input optical radiation or said output optical radiation inside the said multilayer structure and thus enhance the efficiency of the said device.

34. Device for the conversion of optical radiation of claim 1, characterized by the said multilayer structure being equipped with reflectors, oriented parallel to the layers of the said multilayer, situated either side of the multilayer structure to allow the multiple reflection of said surface plasmon-polaritons inside the said multilayer structure and thus enhance the

efficiency of the said device.

35. Device for the conversion of optical radiation of claim 1 and 34, characterized by the said multilayer structure being equipped with reflectors, oriented parallel to the layers of the said multilayer, situated either side of the multilayer structure to allow the multiple reflection of said surface plasmon-polaritons inside the said multilayer structure and thus enhance the efficiency of the said device, in which the reflectors are distributed Bragg reflectors.

36. Device for the conversion of optical radiation of claim 1, characterized by the said multilayer structure being cooled.

37. Device for the conversion of optical radiation of claim 1, characterized by the said means for coupling said input optical radiation into said surface plasmon-polariton modes including a focusing system.

38. Device for the conversion of optical radiation of claim 1, characterized by the said means for coupling said input optical radiation into said surface plasmon-polariton modes including a said focusing system in which the angular divergence of the said incident beam of input optical radiation can be varied.

39. Device for the conversion of optical radiation of claim 1, characterized by the said means for coupling said input optical radiation into said surface plasmon-polariton modes allowing the angle of incidence of the said incident beam of input optical radiation on the said multilayer structure to be varied.

40. Device for the conversion of optical radiation of claim 1, characterized by the said means for coupling said input optical radiation into said surface plasmon-polariton modes including polarizing elements to allow the use of a specific incident state of polarization of the said input optical radiation.

41. Device for the conversion of optical radiation of claim 1 and 40, characterized by the said means for coupling said input optical radiation into said surface plasmon-polariton modes including polarizing elements to allow the use of linearly polarized input optical radiation polarized in the plane of incidence.

42. Device for the conversion of optical radiation of claim 1, characterized by the said means for coupling said input optical radiation into said surface plasmon-polariton modes including a dielectric material that is placed in contact with a surface of the said multilayer structure.

43. Device for the conversion of optical radiation of claim 1 and 42, characterized by the said means for coupling said input optical radiation into said surface plasmon-polariton modes including a said dielectric material that is placed in contact with the said multilayer structure, in which this said dielectric material is in the form of a prism, hemisphere or hemicylinder.

44. Device for the conversion of optical radiation of claim 1 and 42, characterized by the said means for coupling said input optical radiation into said surface plasmon-polariton modes including a said dielectric material that is placed in contact with the said multilayer structure, in which a second dielectric material is placed between the said dielectric material and a surface of the said multilayer structure.

45. Device for the conversion of optical radiation of claim 1, characterized by the said means for coupling said input optical radiation into said surface plasmon-polariton modes including input optical radiation incident on a side of the said multilayer structure.

46. Device for the conversion of optical radiation of claim 1, characterized by the said means for coupling said input optical radiation into said surface plasmon-polariton modes including a periodic grating structure on the surface or inside the said

multilayer structure.

47. Device for the conversion of optical radiation of claim 1, characterized by the said means for coupling output optical radiation out of the said multilayer structure including a focusing system used to collimate the said output optical radiation.

48. Device for the conversion of optical radiation of claim 1, characterized by the said means for coupling output optical radiation out of the said multilayer structure including a dielectric material that is placed in contact with a surface of the said multilayer structure.

49. Device for the conversion of optical radiation of claim 1 and 48, characterized by the said means for coupling output optical radiation out of the said multilayer structure including a said dielectric material that is placed in contact with the said multilayer structure, in which this said dielectric material is in the form of a prism, hemisphere or hemicylinder.

50. Device for the conversion of optical radiation of claim 1 and 48, characterized by the said means for coupling output optical radiation out of the said multilayer structure including a said dielectric material that is placed in contact with the

said multilayer structure, in which a second dielectric material is placed between the said dielectric material and a surface of the said multilayer structure.

51. Device for the conversion of optical radiation of claim 1, characterized by the said means for coupling output optical radiation out of the said multilayer structure including the said output optical radiation exiting from a side of the said multilayer structure.

52. Device for the conversion of optical radiation of claim 1, characterized by the said means for coupling output optical radiation out of the said multilayer structure including a periodic grating structure on the surface or inside the said multilayer structure.

53. Device for the conversion of optical radiation of claim 1, characterized by the said means for coupling output optical radiation out of the said multilayer structure including an optical frequency filtering system.

54. Device for the conversion of optical radiation of claim 1, characterized by the said means for coupling output optical radiation out of the said multilayer structure including an element in common with the said means for coupling said input

optical radiation into said surface plasmon-polariton modes of the said multilayer structure.